AERONAUTICAL AND ASTRONAUTICAL ENGINEER

PRESSURE-SENSITIVE PAINT MEASUREMENT TECHNIQUE DEVELOPMENT FOR TURBOMACHINERY APPLICATION
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Pressure-sensitive paint (PSP) measurement on a transonic compressor rotor required the prior development of phase-locked cumulative imaging using a disk-rotor driven by a high-speed Hamilton-Standard turbine as a developmental test-bed. The turbine was installed in a protective housing in the Gas Dynamics Laboratory and connected to an 8000 cu ft, 300 psi air supply. An hydraulic pump provided bearing lubrication. A once per revolution trigger signal was produced from a light-emitting diode and PIN photodiode pair. The imaging system consisted of an intensified CCD video camera externally triggered by the 1/rev signal via a waveform shaping circuit designed for the present application. Images were captured at camera gate speeds calculated to eliminate pixel blur, and image integration times were varied to optimize image intensity and spatial resolution. Structural and modal analyses of the disk-rotor were conducted and a simplified numerical model of the flow field was computed. Ratioed, colored images were produced for wheel speeds to 20,000 RPM. The effect of the radially varying stagnation temperature was evident, underscoring the importance of quantifying and accounting for the PSP temperature sensitivity so that quantitative pressure data may be obtained. Recommendations for a follow-on program are reported.

KEYWORDS: Pressure Sensitive Paint, Phase-Locked Imaging, Transonic Rotor Measurements, CFD Analysis

DoD KEY TECHNOLOGY AREA: Aerospace Propulsion and Power

MECHANICAL ENGINEER

DEVELOPMENT OF A CONTROL SYSTEM FOR A SHAPE MEMORY ALLOY (SMA) ACTUATED MEDICAL MANIPULATOR

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This thesis discusses the development of a digital control system used to operate a conceptual robotic manipulator for use in minimally invasive surgery. The motion of the manipulator is envisioned to be accomplished with actuators made of a Shape Memory Alloy (SMA). SMA has the ability to recover permanent deformation by undergoing a phase transformation. The recovery of the deformation results in motion of the SMA material which can be exploited for useful work. SMA was chosen as the actuator because it can be miniaturized and has a very high power density as compared to conventional actuators. An Actuator Matrix Driver (AMD) board was designed, as part of the digital control system, to power and control the SMA actuators. The matrix configuration of the AMD architecture and the use of Amplitude Modulated Pulsed (AMP) current allows for a reduction in the number of leads for the powering and control of the actuators. The electrical resistance, a physical property of SMA which characteristically changes with phase transformation, can be used to determine the state or phase of the SMA actuators and can therefore be used for closed loop control.

KEYWORDS: Shape Memory Alloy (SMA), Actuator Matrix Driver (AMD) Board, Amplitude Modulated Pulsed (AMP) Current

DoD KEY TECHNOLOGY AREA: Sensors